DEVELOPMENT OF AUTO RE-CLOSER EARTH LEAKAGE CIRCUIT BREAKER (AR-ELCB)

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Dedicated to
my beloved mother,Yan Bte Awang,
lecturers and friends
for giving a constant source of support and encouragement.

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ABSTRACT

An Earth Leakage Circuit Breaker (ELCB) is an electrical device that disconnects protected circuit whenever it detects unbalance current between the phase conductor and the neutral conductor. Such an unbalance is sometimes caused by current leakage through the body of a person who is grounded when accidentally touching the energized part of the circuit. A lethal shock can result from these conditions. ELCB are designed to disconnect this fault fast enough to mitigate the harm caused by such shocks. Currently, there is no Earth Leakage Circuit Breaker (ELCB) with auto re-closer features in the market. The current ELCB that available in the market is a manual type and cannot differentiate between temporary disturbances and permanent faults. It's means that, if a disturbance or fault occurs on the protected area (house or shop), the protection system will force ELCB to trip. One of the drawbacks of the common ELCB is that, it's can't turn on the power supply back to the normal operation condition although only a short disturbance occurs. Such disturbance is lightning strike on the transmission line in the distribution site near to the protected area. To turn the power back to normal operation, consumers need to do that manually. To overcome this problem, Auto Re-closer Earth Leakage Circuit Breaker (AR-ELCB) has been developed. This thesis presents the development of AR-ELCB. This device was designed to differentiate between permanent fault and short disturbances (lightning).

ABSTRAK

Alat pemutus litar bocor ke bumi (ELCB) ialah sejenis alat yang akan memutuskan litar yang dilindungi apabila ianya mengesan sebarang ketidakstabilan arus antara fasa konduktor dan neutral konduktor. Ketidakstabilan arus biasanya disebabkan oleh kebocoran arus menerusi badan manusia yang secara tidak sengaja tersentuh bahagian litar yang sedang aktif. Ianya boleh menghasilkan kejutan arus elektrik yang membawa kepada maut. ELCB dicipta untuk memutuskan kesilapan ini secepat yang mungkin untuk mengurangkan bahaya yang dihasilkan oleh kesilapan sedemikian. Pada masa sekarang, masih tiada lagi alat pemutus litar kebocoran bumi (ELCB) dengan fungsi penutup automatik di pasaran. ELCB yang terdapat di pasaran sekarang adalah dari jenis yang manual dan tidak dapat membezakan antara gangguan sementara ataupun kerosakan berkekalan. Ini bermakna, jika gangguan ataupun kesilapan berlaku di kawasan perlindungan (rumah ataupun kedai), sistem perlindungan akan menyebabkan ELCB memutuskan litar. Salah satu kekurangan pada ELCB yang biasa ialah, ia tidak boleh mengembalikan bekalan arus kepada keadaan operasi biasa walaupun gangguan yang berlaku hanyalah gangguan kecil sahaja. Contohnya gangguan oleh kilat yang menyambar pada saluran pangiriman di tapak pembahagian arus elektrik berhampiran dengan kawasan perlindungan. Untuk menghidupkan bekalan arus balik pelanggan mestilah melakukannya secara manual. Untuk mengatasi masalah ini alat penutup automatik pemutus litar bocor ke bumi (AR-ELCB) telah dibangunkan. Tesis ini membentangkan tentang pembangunan AR-ELCB. Alat ini dicipta untuk membezakan antara kerosakan berkekalan ataupun gangguan sebentar (kilat).

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V	–	Voltage
ac	–	Alternating Current
dc	–	Direct Current
Ω	–	Ohm
I_i	–	Input Current
Io	–	Output Current
V_{in}	–	Input Voltage
V_o	–	Output Voltage
R_L	–	Load Resistor

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CHAPTER 1

INTRODUCTION

1.1. Project Background

An earth leakage circuit breaker (ELCB), or residual current circuit breaker (RCCB), is an electrical wiring device that disconnects a circuit whenever it detects that the electric current is not balanced between the Live conductor and the Neutral conductor.

ELCB is a tool which helps to prevent electric shock. It will act to cut the electricity supply off to your house if there were any damages to assembly or electrical appliances such as leakage current to earth through live wire contact to electrical appliances frame which could expose the consumer to electric shock. If the wiring at your house is not fitted perfectly or the electrical appliances are low quality, there are probabilities of high current leakage to earth. This could cause electric shock as those described above and could also cause the fire if this state is protracted in the environment which sensitive with heat.

My project is aim to design and develop a unit of auto re-closer earth leakage circuit breaker (ELCB) that can differentiate and act differently with different types of fault. The concept is if there are faulty occurred, the ELCB will trip, if the fault is from

temporary fault type like lightning, ELCB will close back automatically after three seconds. But if the faulty is eternal/permanent fault like from electrical, electronic device or short circuit ELCB will eternally trip and the permanent warning light will on until the fault root cause is cleared and the switch is “on” back by someone again. In this project we have planned to use the microcontroller as a control element.

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1.2. Objectives

The objectives of this project are:

i) To design an ELCB with an auto re-closer unit.
ii) To develop an ARELCB unit.
iii) To fabricate ARELCB for demonstration purpose.

1.3. Scope of Project

The objectives of this project are:

i) The scope of this project is to improve the currently ELCB so that the new ELCB has the ability to turn on back after being trip.
ii) The ARELCB can also distinguish either it is permanent fault or moment fault that occur, so that it will only trigger on when necessary.
iii) To ensure this project work perfectly, Programmable Interface Controller (PIC) and programming will be implement along this project.

1.4. Literature Review

ELCB operate by measuring the current balance between two conductors using a differential current transformer. The device will open its contacts when it detects a difference in current between the line conductor and the neutral conductor. The supply and return currents must sum to zero, otherwise there is a leakage of current to somewhere else (to earth/ground, or to another circuit, etc.).[1]

ELCB is designed to prevent electrocution by detecting the leakage current, which can be far smaller (typically 5–30 milliamperes) than the currents needed to operate conventional circuit breakers or fuses (several amperes). RCDs (Residential Current Device) are intended to operate within 25–40 milliseconds, before electric shock can drive the heart into ventricular fibrillation, the most common cause of death through electric shock.[1]

In the United States, the National Electrical Code, requires GFCI (Ground Fault circuit Interrupter) devices intended to protect people to interrupt the circuit if the leakage current exceeds a range of 4–6 mA of current (the trip setting is typically 5 mA) within 25 milliseconds. ELCB devices which protect equipment (not people) are allowed to trip as high as 30 mA of current. In Europe, the commonly used RCD have trip currents of 10–300 mA.[2]

Residual current detection is complementary to over-current detection. Residual current detection cannot provide protection for overload or short-circuit currents.

ELCB with trip currents as high as 500 mA are sometimes deployed in environments (such as computing centers) where a lower threshold would carry an unacceptable risk of accidental trips. These high-current ELCB serve more as an additional fire-safety protection than as an effective protection against the risks of electrical shocks.[2]

For many years, the voltage operated ELCB and the differential current operated ELCB were both referred to as ELCBs because it was a simpler name to remember. However, the use of a common name for two different devices gave rise to considerable confusion in the electrical industry. If the wrong type was used on an installation, the level of protection given could be substantially less than that intended. To remove this confusion, IEC decided to apply the term Residual Current Device (RCD) to differential current operated ELCBs. Residual current refers to any current over and above the load current. [2]

1.5 Thesis Outline

Chapter 1 discuss about the project background, literature review like the history of ELCB, objective and scope of the project.

Chapters 2 discuss about of Earth Leakage Circuit Breaker (ELCB), the design, the component inside it and also the operation. Besides, this chapter also states the problem with ELCB that make us want to integrate it and about electric fault.

Chapter 3 explains more on the designing and operation of the new AR-ELCB systems. It also describe the functions of each components used in the circuit especially on the ARELCB stage circuit

Chapter 4 describes about another circuit in this project, the control circuit which has PIC18F4550 as the brain of this project. The hardware and the programming software detailed in this topic.

Chapter 5 presents the data and result that have been recorded from the study and some experiments while in development process. The result of this project also is accompanied by the discussions for each problem statements.

Finally in chapter 6, the conclusion has been made for the project from each aspect and there are also suggestions to improve the AR-ELCB on the future, for the commercialization. Costing data also stated in this chapter.

CHAPTER 2

EARTH LEAKAGE CIRCUIT BREAKER

2.1. Introduction

An Earth Leakage Circuit Breaker (ELCB) is a device used to directly detect currents leaking to earth from an installation and cut the power. It was mainly used in TT earthing systems.

In a TT earthing system, the protective earth connection of the consumer is provided by a local connection to earth, independent of any earth connection at the generator.

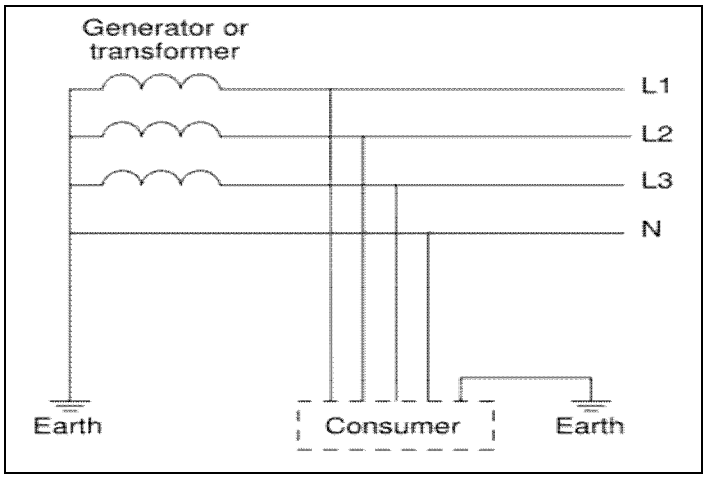

Figure 2.1: TT network

The device could detect the leakage current and protect consumer from electrical shock if leakage current occurred to the consumer equipments. This device will cut off the electrical supply instantaneously when current leakage is detected. There are two types of ELCB:

i) Voltage Earth Leakage Circuit Breaker (vELCB)
ii) Current Earth Leakage Circuit Breaker (iELCB)

2.2 vELCB

vELCB is a voltage operated circuit breaker, the device will function when the Current passes through the ELCB. vELCB contains relay loop which it being connected to the metallic load body at one end and it is connected to ground wire at the other end. If the voltage of the load body is rise which could cause the difference between earth and load body voltage, the danger of electric shock will occur. This voltage difference will produce an electric current from the load metallic body passes the relay loop and to earth. When voltage on the load metallic body raised to the danger level which exceed to 50Volt, the flowing current through relay loop could move the relay contact by disconnecting the supply current to avoid from any danger electric shock.

2.3 iELCB

iELCB is current operated circuit breaker. Current-operated ELCBs are generally known today as RCD (residual current device). These also protect against

earth leakage, though the details and method of operation are different. The device will function with when the Current passes through ELCB. This current admitted to current transform device and on the load. Current from the load also admitted again to transform device. In normal state, total current applied to load is equal with total current out of the load. Because of the balance of in and out of current, it does not affect the current transform device. If there is any earth current leakage caused by earth damage, then the in and out current will no longer in balance. This unbalance current phenomenon will generate the current and if the current exceeded the prescribed rate, the ELCB will jerked and cut off the supply. The device also being called RCD, Residual Current Device in IEC or RCCB, Residual Current Circuit Breaker.

2.4 Problem statements

This device is using mechanical switch that must be switch on manually, after ELCB is being tripped it will stay off until there is someone turn on it back although the problem that occurred is temporary fault and occurred in few millisecond. So, it not works as intelligent device that can operate automatically.

The other problem is ELCB can not distinguish whether the fault is temporary or permanent fault where there are the differentiations between these two types. And do not act differently for these two types of faulty.

2.5. Fault

A fault is any abnormal situation in an electrical system in which the electrical current may or may not flow through the intended parts. Also equipment failure attributable to some defect in a circuit (loose connection or insulation failure or short circuit etc). Types of faults in a distribution network circuit are:

i) Over-load
ii) Line to line fault
iii) Single lines to ground fault
iv) Double line to ground fault

Over-load faults are caused by the unexpected increasing of loads. Faults on electrical equipments are caused by lightning, insulator breakage, Product design which is out of specification and Improper installations of equipments.

Most faults on transmission lines of 100kV and higher are caused by lightning, which results in the flash over of insulators. Transmission lines faults are caused by, lightning, storm, fallen trees, Snow. One of the temporary fault, is a fault lightning. Where example of permanent fault is faults on electrical equipment.

2.6 ELCB Design

Figure 2.2 shows the original of ELCB, the design consists of mechanical switch, ZCT, yellow/ black Box, High level transistor and the reset button. Mechanical switch is a contact of black box, the function of this component is to trigger and cut off the power with cut off the life and neutral line altogether. The function of high level

transistor is to limit the current flowing through its line when the reset button is pushed.

Then the ZCT, the function of this component is to detect the unbalance current in the system and send the signal (induced current) to Black Box. In a black box there is a coil, the coil will activate the mechanical switch after received the minimum current level 100mA (theoretically) from the ZCT. Lastly, there is also reset button, the function of the reset button is to re-set back the device to the initial condition and also as a point to detect whether the device still in good condition or damage/expired. Figure 2.3 show the block diagram of ELCB circuit.

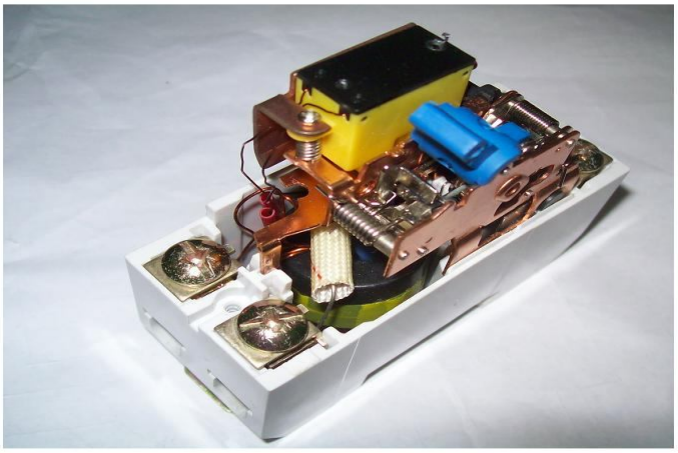

Figure 2.2: Original ELCB

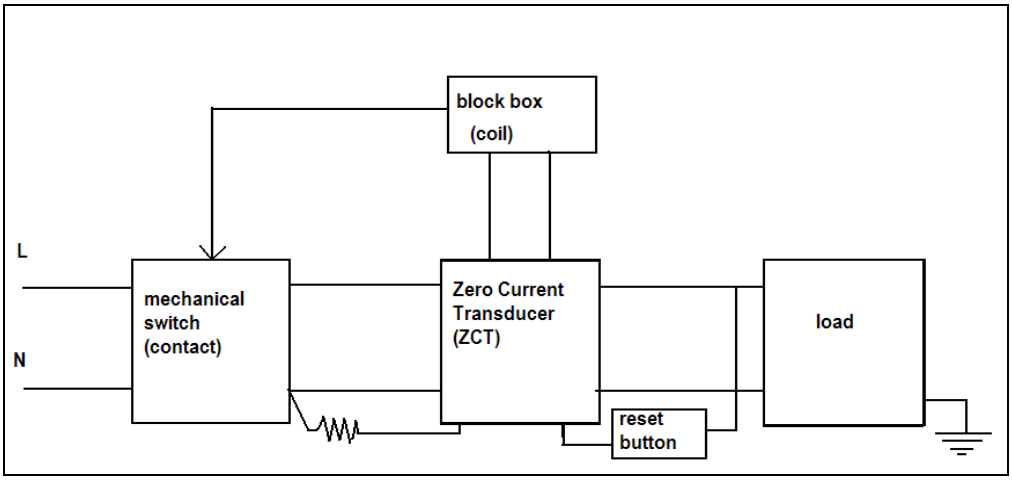

Figure 2.3: Earth Leakage Circuit Breaker design

2.7 Component of ELCB

Old ELCB contain these components to operate:

2.7.1. Zero Current Transducer (ZCT)

The function of this component is to detect the unbalance current in the system and send the signal (induced current) to coil.

2.7.2. Mechanical switch

Mechanical switch is a contact of black box, the function of this component is to trigger and cut off the power with cut off the life and neutral line altogether.

2.7.3. Coil

In a black/yellow box there is a coil, the function of black box is received the signal (induced current) from zero transducer current. The coil is to contact with mechanical switch.

2.7.4. Reset Button

Function of the reset button is to re-set back the device to the initial condition and also as a point to detect whether the device still in good condition or damage/expired.